

# Green tea consumption is associated with lower psychological distress in a general population: the Ohsaki Cohort 2006 Study<sup>1–3</sup>

Atsushi Hozawa, Shinichi Kuriyama, Naoki Nakaya, Kaori Ohmori-Matsuda, Masako Kakizaki, Toshimasa Sone, Masato Nagai, Yumi Sugawara, Akemi Nitta, Yasutake Tomata, Kaijun Niu, and Ichiro Tsuji

## ABSTRACT

**Background:** Although green tea or its constituents might reduce psychological stress, the relation between green tea consumption and psychological distress has not been investigated in a large-scale study.

**Objective:** Our aim was to clarify whether green tea consumption is associated with lower psychological distress.

**Design:** We analyzed cross-sectional data for 42,093 Japanese individuals aged  $\geq 40$  y from the general population. Information on daily green tea consumption, psychological distress as assessed by the Kessler 6-item psychological distress scale, and other lifestyle factors was collected by using a questionnaire. We used multiple logistic regression analyses adjusted for age, sex, history of disease, body mass index, cigarette smoking, alcohol consumption, time spent walking, dietary factors, social support, and participation in community activities to investigate the relation between green tea consumption and psychological distress.

**Results:** We classified 2774 (6.6%) of the respondents as having psychological distress (Kessler 6-item psychological distress scale  $\geq 13/24$ ). There was an inverse association between green tea consumption and psychological distress in a model adjusted for age and sex. Although the relation was largely attenuated when possible confounding factors were adjusted for, a statistically significant inverse association remained. The odds ratio (with 95% CI) of developing psychological distress among respondents who consumed  $\geq 5$  cups of green tea/d was 0.80 (0.70, 0.91) compared with those who consumed  $< 1$  cup/d. These relations persisted when respondents were stratified by social support subgroups or by activities in communities.

**Conclusion:** Green tea consumption was inversely associated with psychological distress even after adjustment for possible confounding factors. *Am J Clin Nutr* 2009;90:1390–6.

## INTRODUCTION

Mental health is an important component of overall well-being (1). Thus, to determine risk factors for impaired mental health or psychological distress is an important task.

Kessler et al (2) recently compared the projected lifetime risk of any mental disorder as assessed by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) in 17 countries. The risk was the lowest in metropolitan areas in China (18.0%), Nigeria (19.5%), and Japan (24.4%). These values were lower than other countries, such as the United States (55.3%), France (47.2%), and Germany (33.0%). This suggests

that some cultural or lifestyle-related features of Japan, such as dietary habit, personality, or social capital, might have a positive effect on mental disorders.

Among these features, green tea consumption is a traditional part of the Japanese lifestyle (3–5), and it has long been considered that drinking green tea is associated with stress relief (6). Actually, recent trials suggest that tea consumption (6) or supplementation with L-theanine (7), which is a constituent of green tea, reduces responses to acute psychological stress when assessed as post-task cortisol (6), heart rate, and salivary immunoglobulin-A (7). Therefore, green tea consumption might be able to reduce psychological distress. However, large-scale studies have not investigated the relation between green tea and psychological distress in the general population. One reason for this might be the difficulties with assessing psychological distress in a general population. However, Kessler et al (8, 9) have developed a short form of screening scales to monitor the prevalence of psychological distress in populations [the Kessler 6-item psychological distress scale (K6)], which we applied in the present study to investigate whether green tea consumption is associated with a lower psychological distress.

## SUBJECTS AND METHODS

### Study design, setting, and participants

The design of the Ohsaki Cohort 2006 Study has been described in detail (10). In brief, the source population for the

<sup>1</sup> From the Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan (AH, SK, NN, KO-M, MK, TS, MN, YS, AN, YT, and IT), and the Department of Medicine and Science in Sports and Exercise, Tohoku University Graduate School of Medicine, Sendai, Japan (KN).

<sup>2</sup> Supported by Health Sciences Research grants (nos. H21-Choju-Ippan-001, H19-Seisaku-Ippan-026, and H18-Choju-Ippan-014) from the Ministry of Health, Labour and Welfare of Japan and by a Grant-in-Aid for Scientific Research (B) (18390191) from the Japan Society for the Promotion of Science.

<sup>3</sup> Address correspondence to A Hozawa, Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine 2-1, Seiryomachi, Aoba-ku, Sendai, Miyagi 980-8575, Japan. E-mail: hozawa-thk@umin.ac.jp.

Received June 11, 2009. Accepted for publication August 28, 2009.

First published online September 30, 2009; doi: 10.3945/ajcn.2009.28214.

baseline survey comprised all men and women aged  $\geq 40$  y living in Ohsaki City, northeastern Japan, on 1 December 2006.

The baseline survey was conducted between 1 December and 15 December 2006. A questionnaire was distributed by the heads of individual administrative districts to individual households and collected by mail. Of the eligible 77,235 respondents, the 49,855 (26,512 men and 23,343 women; 64.5%) who provided valid responses formed the study cohort. Of the 49,855 respondents, 43,716 (87.7%) completed the K6. We excluded 1623 persons who did not complete the questionnaire regarding green tea consumption. Thus, 42,093 responses were analyzed in this study.

### Measurement of psychological distress

The K6 was used as an indicator of psychological distress (8, 9). Respondents were asked about their mental status over the last month by using 6 questions to which they responded by choosing “all of the time” (4 points), “most of the time” (3 points), “some of the time” (2 points), “a little of the time” (1 point), and “none of the time” (0 points). Total point scores ranged from 0 to 24. The questions were as follows: “Over the last month, how often have you felt the following? 1) nervous, 2) hopeless, 3) restless or fidgety, 4) so sad that nothing could cheer you up, 5) that everything was an effort, and 6) worthless. The K6 is based on modern psychometric theory and has already outperformed some existing scales (8, 9). The Japanese version of the K6 was recently developed by using the standard back-translation method and has been validated (11). As suggested by Kessler et al (9), we classified individuals with scores of  $\geq 13/24$  as having psychological distress (10). Furukawa et al (12) investigated whether K6 was able to predict 30-d disorders of the DSM-IV as assessed by the World Health Organization Composite International Diagnostic Interview in the Australian National Survey. They showed that K6 was able to detect Composite International Diagnostic Interview/DSM-IV mood and anxiety disorders (area under the receiver operating curve: 0.89; 95% CI: 0.88, 0.90) better than the General Health Questionnaire 12 (AUC: 0.80; 95% CI: 0.78, 0.82).

### Measurements of other types of exposure

The survey included questions about the frequency of recent average consumption of green tea, oolong tea, black tea, coffee, and 36 food items, as well as questions regarding alcohol and tobacco consumption, history of disease, body weight, height, and time spent walking per day. The food-frequency questionnaire did not cover a specific period of time but asked about “daily diet.” The frequency of green tea consumption was categorized as never, occasionally, or 1–2, 3–4, and  $>5$  cups/d. Within the study region, the volume of a typical cup of green tea is 100 mL.

We conducted a validation study of the food-frequency questionnaire, in which 113 respondents provided four 3-d food records within a period of 1 y and subsequently responded to the questionnaire. The Spearman rank coefficient for the correlation between amounts of consumed green tea according to the questionnaire and amounts consumed according to the food records was 0.71 for men and 0.53 for women; the correlation between consumption measured by the 2 questionnaires administered 1 y apart was 0.63 for men and 0.64 for women (13).

Body mass index was calculated as the self-reported body weight (kg) divided by the square of the self-reported body height (m).

The degree of social support available to each individual was assessed by asking the following (14): Do you have someone 1) whom you can talk to when you are in trouble? 2) whom you can consult when you do not feel well? 3) who can help you with your daily housework? 4) who can take you to a hospital when you feel ill? and 5) who can take care of you if you become bedridden? This social support questionnaire consisted of 5 questions, each requiring a “yes” or “no” answer. This questionnaire was available only in Japanese. The validity and reliability of the questionnaire were not evaluated.

We also assessed participation in community activities. We asked about how often the respondent participates in the following activities: 1) neighborhood associations; 2) sports, exercise, or a hobby; 3) volunteering for nonprofit organizations; and 4) participation in other social gatherings. The frequency of these activities was assessed as never, a few times each year, monthly, 2–3 times/month, 1 time/wk, 2–3 times/wk, and  $\geq 4$  d/wk.

### Ethical issues

We considered the return of completed questionnaires to imply the consent to participate in the study involving a cross-sectional analysis of the baseline survey data and subsequent follow-up of mortality and emigration. The Ethics Committee of Tohoku University Graduate School of Medicine reviewed and approved the study protocol.

### Statistical analysis

Baseline characteristics were evaluated by using the analysis of variance for continuous variables and the chi-square test for categorical variables. We also used age-sex-adjusted logistic regression analyses to clarify the age-sex-adjusted relation between green tea consumption and history of diseases. We used multivariate logistic regression analysis to calculate the odds ratios (ORs) and 95% CIs for having psychological distress (a K6 total score of  $\geq 13/24$ ) according to categories of green tea consumption. We established respondents who consumed  $<1$  cup/d green tea as the reference category and examined the relation between green tea consumption and psychological distress by using the following models. Model 1 was age-sex adjusted. Model 2 was adjusted for the following physical risk factors: sex; age (40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and  $\geq 85$  y); history of hypertension (“yes,” “no”), diabetes mellitus (“yes,” “no”), stroke (“yes,” “no”), myocardial infarction (“yes,” “no”), and cancer (“yes,” “no”); smoking status (“never,” “former,” “current,” “missing”); alcohol consumption (“never,” “former,” “current,” “missing”); body mass index (in  $\text{kg}/\text{m}^2$ :  $<18.5$ , 18.5–24.9,  $\geq 25.0$ , missing); and time spent walking ( $<30$  min/d, 30 min to 1 h/d,  $\geq 1$  h/d, missing). Model 3 was further adjusted for dietary factors, namely volume of rice intake and frequency of consumption of miso soup, red meat, chicken, fish, green or yellow vegetable, soy products, fruit, coffee, black tea, and oolong tea. Model 4 was fully adjusted and included the answers to the questions about social support (“yes,” “no support,” “missing”) and participation in community activities (“yes,” “never,” “missing”).

**TABLE 1**Relation between green tea consumption and the characteristics of the participants of the Ohsaki Cohort 2006 Study<sup>1</sup>

	Green tea consumption (cups/d)				P
	<1 (n = 10,770)	1–2 (n = 12,007)	3–4 (n = 10,364)	>5 (n = 8952)	
Age (y)	58.5 ± 12.5 <sup>2</sup>	59.9 ± 12.5	64.6 ± 12.0	67.5 ± 10.8	<0.01
Women [n (%)]	5090 (47)	6093 (51)	5954 (57)	5742 (64)	<0.01
Smoking [n (%)]					
Current	3249 (30)	2829 (24)	1787 (17)	1323 (15)	<0.01
Former	2319 (22)	2589 (22)	2126 (21)	1633 (18)	
Never	4749 (44)	5991 (50)	5721 (55)	5202 (58)	
Alcohol drinking [n (%)]					
Current	5797 (54)	6415 (53)	4573 (44)	3266 (36)	<0.01
Former	1020 (9)	886 (7)	802 (8)	749 (8)	
Never	3603 (33)	4244 (35)	4404 (42)	4311 (48)	
BMI [n (%)]					
18.5 kg/m <sup>2</sup>	506 (5)	455 (4)	405 (4)	375 (4)	<0.01
18.5–24.9 kg/m <sup>2</sup>	6517 (61)	7454 (62)	6322 (61)	5376 (60)	
≥25 kg/m <sup>2</sup>	3077 (29)	3420 (28)	2875 (28)	2466 (28)	
Time spent walking >1 h [n (%)]	3074 (29)	3209 (27)	2717 (26)	2539 (28)	<0.01
History of diseases [n (%)]					
Hypertension	2610 (24)	3191 (27)	3296 (32)	3139 (35)	<0.01
Diabetes mellitus	850 (8)	966 (8)	981 (9)	867 (10)	<0.01
Stroke	278 (3)	269 (2)	233 (2)	183 (2)	<0.01
Myocardial infarction	243 (2)	261 (2)	307 (3)	267 (3)	<0.01
Cancer	483 (4)	571 (5)	656 (6)	643 (7)	<0.01
Volume of rice intake [n (%)]					
>3 bowls/d	1107 (10)	1135 (9)	882 (9)	687 (8)	<0.01
Consumed miso soup almost every day [n (%)]	7790 (72)	9585 (80)	8756 (84)	7715 (86)	<0.01
Frequency of food intake [n (%)]					
Red meat (at least once/wk)	8910 (83)	10225 (85)	8901 (86)	7579 (85)	<0.01
Chicken (at least once/wk)	6163 (57)	7266 (61)	6387 (62)	5432 (61)	<0.01
Fish (almost every day)	1867 (17)	2470 (21)	2814 (27)	3211 (36)	<0.01
Green yellow vegetable (almost every day)	3097 (29)	4176 (35)	4526 (44)	4795 (54)	<0.01
Soy products (almost every day)	4314 (40)	5750 (48)	5971 (58)	5859 (65)	<0.01
Fruit (almost every day)	2509 (17)	3673 (31)	4210 (41)	4626 (52)	<0.01
Frequency of beverage intake [n (%)]					
Coffee ≥1 cup/d	7749 (72)	8843 (74)	6586 (64)	4796 (54)	<0.01
Black tea ≥1 cup/d	937 (9)	2173 (18)	1875 (18)	1677 (19)	<0.01
Oolong tea ≥1 cup/d	1507 (14)	2304 (19)	1845 (18)	1714 (19)	<0.01
Social support [n (%)]					
To consult when you are in trouble (no)	1690 (16)	1567 (13)	1061 (10)	764 (9)	<0.01
To consult when you are in bad physical condition (no)	1335 (12)	1214 (10)	812 (8)	594 (7)	<0.01
To help with your daily housework (no)	1903 (18)	1834 (15)	1476 (14)	1163 (13)	<0.01
To take you to a hospital (no)	1188 (11)	1057 (9)	782 (8)	637 (7)	<0.01
To take care of you (no)	1498 (14)	1460 (12)	1259 (12)	1096 (12)	<0.01
Participation in community activities [n (%)]					
Activities in neighborhood association (any yes)	4659 (43)	5681 (47)	5120 (49)	4352 (49)	<0.01
Sports or exercise (any yes)	4140 (38)	5283 (44)	4707 (45)	4005 (45)	<0.01
Volunteers (any yes)	2854 (27)	3588 (30)	3189 (31)	2736 (22)	<0.01
Social gathering (any yes)	4061 (38)	5271 (44)	4698 (45)	4081 (46)	<0.01

<sup>1</sup> For smoking, alcohol drinking, and BMI, the sum of the number of participants did not match all numbers of participants due to missing information.<sup>2</sup> Mean ± SD (all such values).

We used several dummy variables to adjust for the aforementioned factors.

Because we considered that social support or community activities might modify the relation between green tea and psychological distress, we further stratified the responses by social support (support in all 5 social support categories and perception of not being supported in ≥1 of 5 social support categories) and community activity (participation in at least one community activity or none) to confirm the relation between green tea con-

sumption and psychological distress. Those who did not answer any questions about social support or participation in community activities were excluded when stratified by social support and participation in communities, respectively. In an analysis of social support and participation in community activities, neither of these was used as the respective covariate. When we calculated the interaction of green tea with social support and participation in community activities, we used cross-product terms of green tea and social support or participation in community activities.

We also analyzed the relation between black tea consumption and psychological distress by using a fully adjusted model (model 4). All data were statistically analyzed by using SAS version 9.1 (SAS Inc, Cary, NC). All statistical tests described here were 2-sided, and  $P < 0.05$  was accepted as statistically significant.

## RESULTS

The association between green tea consumption and other lifestyle factors is shown in **Table 1**. The mean age, the proportion of women, the proportion of those who had never smoked or never consumed alcohol, as well as the frequency of a history of hypertension and cancer were higher among those who more frequently consumed green tea. This group also consumed more fish, soy products, green and yellow vegetables, and fruit and participated more often in community activities. Conversely, fewer respondents who consumed more green tea felt a lack of social support. Because the relation between green tea consumption and a history of diseases might be strongly confounded by age, we conducted age-sex-adjusted logistic regression analyses. The relation of green tea consumption to hypertension, diabetes, and myocardial infarction was no longer statistically significant when adjusted for age and sex ( $P$  for trends  $\geq 0.13$ ). However, the inverse association between green tea consumption and history of stroke ( $P < 0.001$ ) and the positive relation between green tea consumption and history of cancer ( $P = 0.007$ ) remained statistically significant.

Overall, 2774 (6.6%) respondents were considered to have psychological distress ( $K6 \geq 13$ ). The prevalence was the highest (8.4%) and lowest (5.1%) among those who consumed  $<1$  and  $\geq 5$  cups green tea/d, respectively (see **Table 2**). The age-sex-

adjusted model (model 1) revealed a close inverse relation between green tea consumption and having psychological distress. In comparison with individuals who consumed  $<1$  cup/d, the ORs (95% CI) of having psychological distress for those who consumed 1–2, 3–4, and  $\geq 5$  cups/d were 0.79 (0.71, 0.87), 0.68 (0.61, 0.76), and 0.59 (0.52, 0.67), respectively. Although these associations were attenuated when adjusted for other lifestyle factors or a history of disease (model 2), the significant inverse association persisted ( $P$  for trend  $< 0.001$ ). Although adjustment for dietary factors (model 3) and for social support or participation in community activities (model 4) also attenuated the relation, the inverse association between green tea consumption and psychological distress persisted (both  $P$ 's for trend were  $< 0.001$ ). The adjusted ORs (95% CI) for psychological distress in subjects who consumed 1–2, 3–4, and  $\geq 5$  cups of green tea/d were 0.95 (0.86, 1.06), 0.89 (0.79, 1.00), and 0.80 (0.70, 0.91), respectively, in model 4, compared with the reference group.

To confirm whether the relation between green tea consumption and psychological distress persisted irrespective of social support or participation in community activities, we also investigated the association stratified in a subgroup by these 2 factors (**Table 3**). Neither an interaction between green tea consumption and social support for psychological distress ( $P = 0.91$ ) nor an interaction between green tea consumption and participation in community activities for psychological distress ( $P = 0.08$ ) was statistically significant.

We also analyzed the relation between the consumption of black tea and psychological distress. Compared with participants who consumed  $<1$  cup black tea/d ( $n = 35,431$ ), the ORs (95% CI) for those who consumed 1–2 cups black tea/d ( $n = 2161$ ), and  $\geq 3$  cups black tea/d ( $n = 516$ ) were 1.14 (0.95, 1.36) and 1.11 (0.78, 1.58), respectively.

**TABLE 2**

Relation between green tea consumption and psychological distress, as assessed by the Kessler 6-item psychological distress scale (K6), in the Ohsaki Cohort 2006 Study<sup>1</sup>

	Green tea consumption (cups/d)				<i>P</i> for trend
	$<1$ ( $n = 10,770$ )	1–2 ( $n = 12,007$ )	3–4 ( $n = 10,364$ )	$>5$ ( $n = 8952$ )	
No. of participants with psychological distress ( $K6 \geq 13$ )	902	808	604	460	—
Prevalence of psychological distress (%)	8.4	6.7	5.8	5.1	—
Model 1 <sup>2</sup>	Ref	0.79 (0.71, 0.87) <sup>3</sup>	0.68 (0.61, 0.76)	0.59 (0.52, 0.67)	$<0.001$
Model 2 <sup>4</sup>	Ref	0.83 (0.75, 0.92)	0.73 (0.65, 0.81)	0.64 (0.57, 0.72)	$<0.001$
Model 3 <sup>5</sup>	Ref	0.91 (0.82, 1.01)	0.83 (0.74, 0.93)	0.73 (0.64, 0.83)	$<0.001$
Model 4 <sup>6</sup>	Ref	0.95 (0.86, 1.06)	0.89 (0.79, 1.00)	0.80 (0.70, 0.91)	$<0.001$

<sup>1</sup> Ref, referent.

<sup>2</sup> Adjusted for age categories (40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and  $\geq 85$  y) and for sex.

<sup>3</sup> Odds ratio; 95% CI in parentheses (all such values).

<sup>4</sup> Same as model 1 + history of hypertension (yes, no), history of diabetes mellitus (yes, no), history of stroke (yes, no), history of myocardial infarction (yes, no), history of cancer (yes, no), smoking status (never, former, current, missing), alcohol consumption (never, former, current, missing), BMI (in  $\text{kg}/\text{m}^2$ ;  $<18.5$ , 18.5–24.9,  $\geq 25.0$ , missing), and time spent walking ( $<30$  min/d, 30 min–1 h/d,  $\geq 1$  h/d, missing).

<sup>5</sup> Same as model 2 + volume of rice intake, frequency of consumption of miso soup, red meat, chicken, fish, green and yellow vegetable, soy product, fruit, coffee, black tea, and oolong tea.

<sup>6</sup> Same as model 3 + social support [ie, 1) Do you have someone with whom you can consult when you are in trouble? (yes, no, missing), 2) Do you have someone with whom you can consult when your physical condition is not good? (yes, no, missing), 3) Do you have someone who can help you with your daily housework? (yes, no, missing), 4) Do you have someone who can take you to a hospital when you do not feel well? (yes, no, missing), and 5) Do you have someone who can take care of you when you are ill in bed? (yes, no, missing)] and participation in community activities [ie, How often do you participate in the following activities? 1) activities in neighborhood association (any yes, never, missing), 2) sports, exercise, or hobby (any yes, never, missing), 3) volunteer for a nonprofit organization (any yes, never, missing), and 4) other social gatherings (any yes, never, missing)].

**TABLE 3**

Relation between green tea consumption and psychological distress, as assessed by the Kessler 6-item psychological distress scale (K6), stratified by social support and community activity subgroup in the Ohsaki Cohort 2006 Study<sup>1</sup>

	Green tea consumption (cups/d)				<i>P</i> for trend
	<1	1–2	3–4	>5	
<b>Social support<sup>2</sup></b>					
No lack					
No. of participants	7466	8723	7799	6839	
No. of participants with psychological distress (K6 ≥ 13)	414	422	312	259	
Prevalence of psychological distress (%)	5.5	4.8	4.0	3.8	
Multiple adjusted OR (95% CI) <sup>3</sup>	Ref	0.99 (0.86, 1.15)	0.86 (0.73, 1.01)	0.81 (0.68, 0.96)	0.005
Any lack					
No. of participants	3283	3255	2544	2098	
No. of participants with psychological distress (K6 ≥ 13)	484	383	291	201	
Prevalence of psychological distress (%)	14.7	11.8	11.4	9.6	
Multiple adjusted OR (95% CI) <sup>3</sup>	Ref	0.89 (0.77, 1.04)	0.94 (0.80, 1.11)	0.77 (0.64, 0.94)	0.02
<b>Participation in community activities<sup>2</sup></b>					
Participated					
No. of participants	6830	8281	7285	6246	
No. of participants with psychological distress (K6 ≥ 13)	370	383	288	197	
Prevalence of psychological distress (%)	5.4	4.6	4.0	3.2	
Multiple adjusted OR (95% CI) <sup>3</sup>	Ref	0.99 (0.85, 1.15)	0.98 (0.83, 1.16)	0.82 (0.67, 0.998)	0.08
Did not participate					
No. of participants	3759	3499	2876	2491	
No. of participants with psychological distress (K6 ≥ 13)	500	387	297	245	
Prevalence of psychological distress (%)	13.3	11.1	10.3	9.8	
Multiple adjusted OR (95% CI) <sup>3</sup>	Ref	0.93 (0.80, 1.08)	0.87 (0.73, 1.02)	0.82 (0.69, 0.98)	0.02

<sup>1</sup> OR, odds ratio; Ref, referent; “No lack,” participants who perceived that they were supported for all 5 social support categories; “Any lack,” participants who perceived that they were not supported for at least one social support category; “Participated,” participants who participated in at least one community activity; “Did not participate,” participants who did not participate in any community activities.

<sup>2</sup> Social support and participation in community activities were not used as covariates in analyses. *P* values for interaction for social support and participation in community activities were 0.91 and 0.08, respectively.

<sup>3</sup> Model 4 in Table 2 was used for adjustment.

## DISCUSSION

We identified an inverse relation between green tea consumption and psychological distress as assessed by K6 in a large-sample cross-sectional study of a Japanese population. We considered that green tea consumption might contribute, at least in part, to a low lifetime risk of any mental disorder in Japan (2).

The main strength of our study is that we investigated a large sample of the general population, which allowed the consideration of many confounding factors, including social support and participation in community activities. Another strength is that we used a practical and tested questionnaire to assess psychological distress (8, 9). Of the 49,855 respondents, 88% completed the K6 [the 6-item scale developed by Kessler et al (8, 9)], which enabled an assessment of risk factors for psychological distress in a general population.

To understand whether green tea was inversely and independently related to psychological distress, we attempted several approaches to control confounding. First, we tested the effects of comorbidities or lifestyle factors on the relation. Both green tea consumption and psychological distress are inversely related with a history of cardiovascular diseases (CVDs) (10) and risk factors for CVD (10, 15, 16). Furthermore, we already reported that green tea consumption is inversely related with CVD mortality (4). Thus, CVD or risk factors for CVD can be confounding factors of the relation between green tea and psychological distress. However, the association persisted although

adjustment for these factors attenuated the inverse relation between green tea consumption and psychological distress. Therefore, we considered that the relation was independent of CVD or these risk factors.

We also considered confounding by other dietary factors. Adjustments for other foods were required because the consumption of green tea might be associated with that of other Japanese foods, such as fish or soy products (5). Furthermore, the effect of other beverages on psychological distress also should be adjusted. However, adjustment for dietary factors and beverages did not fully explain the inverse relation between green tea and psychological distress. Therefore, we considered that the relation was independent of other dietary factors or beverages.

Third, we considered the effect of social support or community activities. Because green tea is the most likely beverage to be served during social activities in Japan, its consumption might be merely a marker of social support or community activity (3). In fact, our cross-sectional analyses have already shown a close inverse relation between psychological distress and social support or activities in the community (10). Thus, consideration of these factors is also important to understanding the relation between green tea consumption and psychological distress. However, we show that the inverse association between green tea consumption and psychological distress persisted even after further adjustment for social support and participation in community activities, irrespective of social support subgroup or

subgroup of community activities. Therefore, although other residual confounding factors might exist, we considered that green tea consumption was inversely and independently related to psychological distress.

Only one study has described a relation between green tea consumption and mental illness (17). Shimbo et al (17) investigated 380 Japanese individuals aged 20–69 y and assessed the relation between green tea consumption and a Japanese version of the General Health Questionnaire 12. Although they show that brewed green tea consumption was inversely associated with mental illness (OR: 0.78 for males and 0.77 for females), the relation was not statistically significant. Because the point estimate was large, Shimbo et al (17) might have detected a significant association if a sufficiently large sample had been investigated. Thus, although the assessment methods were different, we considered that our results agreed with their findings.

Some clinical trials have examined the effect of tea (6), L-theanine (7), or high doses of ascorbic acid (18) on responses to psychological stress. Both L-theanine and ascorbic acid are constituents of green tea (16). An investigation of the influence of black tea compared with a caffeine-matched placebo on both acute biological responses and the rate of poststress recovery by using double-blind methodology (6) discovered that 6 wk of tea consumption leads to lower poststress cortisol and greater subjective relaxation. Kimura et al (7) examined whether L-theanine influences the physiologic response under stress by using a mental arithmetic task as an acute stressor. They show that L-theanine intake resulted in a reduction in heart rate and salivary immunoglobulin A responses to an acute stress task relative to a placebo control. Brody et al (18) reported that high-dose ascorbic acid palliates blood pressure, cortisol, and subjective responses to acute psychological stress. These studies consistently show that the acute response to psychological stress was reduced in a group provided with tea or tea constituents. Because reducing physiologic stress might result in reduced psychological distress, these data could be considered as evidence that supports our findings.

These results from clinical trials also suggested that not only green tea but also black tea might have a beneficial effect on psychological distress because the constituents of the 2 types of tea are similar (16). In fact, Hintikka et al (19) have reported an inverse relation between the daily consumption of black tea and the risk of depression, as assessed by a postal questionnaire and the Beck Depression Inventory in a relatively large general Finnish population sample. In our study, however, we did not find any relation between consumption of black tea and psychological distress. We considered that the lack of such an association was due to the less-frequent consumption of black tea in Japan. Any relation between black tea and psychological distress might be masked by frequent consumption of green tea.

This study has some limitations. The first was the cross-sectional design. We could not conclude whether green tea reduces psychological distress or whether individuals without psychological distress are more likely to consume green tea. However, because we clarified an inverse relation between green tea consumption and psychological distress irrespective of social support and participation in community activities, we considered that green tea has a beneficial effect on psychological distress. A prospective study or a clinical trial is required to confirm this notion. Second, the correlation between the amounts of green tea

consumed according to the questionnaire and the amounts consumed according to the 3-d food records was not very high (men: 0.71; women: 0.53), especially in women. Because green tea consumption varied day by day, we considered that a certain difference could be acceptable for green tea consumption. However, in any case, questionnaire surveys have some misclassifications regarding green tea consumption. Due to this limitation, we might have underestimated the inverse relation between green tea consumption and psychological distress in this study. Third, although we claimed that social support is an important confounding factor and we stratified according to this variable, the variable is not validated. However, the questionnaire comprised simple questions, and therefore we considered that it could be used for the assessment of social support. In conclusion, we showed that green tea consumption was inversely associated with psychological distress in a cross-sectional study of a large Japanese population.

We thank Yoshiko Nakata, Mika Wagatsuma, and Tomoko Muroi for their technical assistance.

The authors' responsibilities were as follows—AH, SK, NN, and IT: conception and design; SK, NN, KO-M, MK, and TS: acquisition of data; AH, SK, NN, and KN: analysis and interpretation of data; AH: drafting of the manuscript; SK, NN, KO-M, MK, TS, MN, YS, AN, YT, KN, and IT: critical revision of the manuscript for intellectual content; AH: statistical analysis; and IT: obtaining funding and supervision. None of the authors had a conflict of interest.

## REFERENCES

- Pratt LA, Dey AN, Cohen AJ. Characteristics of adults with serious psychological distress as measured by the K6 scale: United States, 2001–04. *Adv Data* 2007;382:1–18.
- Kessler RC, Angermeyer M, Anthony JC, et al. Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry* 2007;6:168–76.
- Kuriyama S, Hozawa A, Ohmori K, et al. Green tea consumption and cognitive function: a cross-sectional study from the Tsurugaya Project. *Am J Clin Nutr* 2006;83:355–61.
- Kuriyama S, Shimazu T, Ohmori K, et al. Green tea consumption and mortality due to cardiovascular disease, cancer, and all causes in Japan: the Ohsaki study. *JAMA* 2006;296:1255–65.
- Shimazu T, Kuriyama S, Hozawa A, et al. Dietary patterns and cardiovascular disease mortality in Japan: a prospective cohort study. *Int J Epidemiol* 2007;36:600–9.
- Stephoe A, Gibson EL, Vuononvirta R, et al. The effects of tea on psychophysiological stress responsivity and post-stress recovery: a randomised double-blind trial. *Psychopharmacology (Berl)* 2007;190:81–9.
- Kimura K, Ozeki M, Juneja LR, Ohira H. L-Theanine reduces psychological and physiological stress responses. *Biol Psychol* 2007;74:39–45.
- Kessler RC, Andrews G, Colpe LJ, et al. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychol Med* 2002;32:959–76.
- Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch Gen Psychiatry* 2003;60:184–9.
- Kuriyama S, Nakaya N, Ohmori-Matsuda K, et al. Factors associated with psychological distress as measured by the K6 scale in a community-dwelling population: a cross-sectional study from the Ohsaki Cohort 2006 Study. *J Epidemiol (in press)*.
- Furukawa TA, Kawakami N, Saitoh M, et al. The performance of the Japanese version of the K6 and K10 in the World Mental Health Survey Japan. *Int J Methods Psychiatr Res* 2008;17:152–8.
- Furukawa TA, Kessler RC, Slade T, Andrews G. The performance of the K6 and K10 screening scales for psychological distress in the Australian National Survey of Mental Health and Well-Being. *Psychol Med* 2003;33:357–62.

13. Ogawa K, Tsubono Y, Nishino Y, et al. Validation of a food-frequency questionnaire for cohort studies in rural Japan. *Public Health Nutr* 2003;6:147–57.
14. Muraoka Y, Ikichi A, Ihara K. The physical and psychological and social background factor of elderly depression in the community. *Ronen Seishin Igaku Zasshi* 1996;7:397–407 (in Japanese).
15. Imai K, Nakachi K. Cross sectional study of effects of drinking green tea on cardiovascular and liver diseases. *BMJ* 1995;310:693–6.
16. Cooper R, Morr  DJ, Morr  DM. Medicinal benefits of green tea: Part I. Review of noncancer health benefits. *J Altern Complement Med* 2005; 11:521–8.
17. Shimbo M, Nakamura K, Jing Shi H, et al. Green tea consumption in everyday life and mental health. *Public Health Nutr* 2005;8: 1300–6.
18. Brody S, Preut R, Schommer K, Sch rmeyer TH. A randomized controlled trial of high dose ascorbic acid for reduction of blood pressure, cortisol, and subjective responses to psychological stress. *Psychopharmacology (Berl)* 2002;159:319–24.
19. Hintikka J, Tolmunen T, Honkalampi K, et al. Daily tea drinking is associated with a low level of depressive symptoms in the Finnish general population. *Eur J Epidemiol* 2005;20:359–63.